Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

SHOUT
SHARE
IT

0848
274
110.1

UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 274

Washington, D. C.

Issued, July 8, 1915.
Revised, July 7, 1924.

FACTORS GOVERNING THE SUCCESSFUL SHIPMENT OF RED RASPBERRIES FROM THE PUYALLUP VALLEY.[1]

By H. J. RAMSEY, *Pomologist in Charge of Fruit-Handling and Storage Investigations, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

CONTENTS.

	Page.		Page.
Introduction	1	The labor problem	18
The berry industry of the Puyallup Valley	2	Handling, an economic problem	18
Methods of growing red raspberries	4	Careful-handling experiments	18
Handling and shipping red raspberries	8	Effect of delay in cooling on keeping quality	23
Causes of decay of fruit in transit	13	Precooling experiments	24
Frequency of picking	16	Decay in top and bottom crates	28
Relation of rainfall to handling	17	Temperature conditions in an iced refrigerator car	29
Relation of methods of growing to keeping quality	17	The application of precooling	30
		Summary	31

INTRODUCTION.

Berry growing is the leading horticultural industry in the Puyallup Valley, Wash., and is rapidly increasing in importance in other sections of that State and in Oregon and California. The growth of this industry, as well as the prosperity of the community, in the Puyallup Valley especially, is dependent largely on the extension and broadening of the marketing zone for fresh berries. The carrying and keeping qualities of the berries produced and offered for shipment determine the territory and markets that can be profitably reached. Under the ordinary and usual methods of handling and refrigeration 2,000 miles has been the limit of successful shipment for red raspberries, and oftentimes considerable deterioration and decay occurred at this or lesser distances.

The markets for fresh berries could not profitably be extended without better keeping or carrying qualities. Many leading growers have felt that possibly changes in methods of handling and refrig-

[1] B. B. Pratt and A. W. McKay, formerly Pomologists in Fruit-Handling and Storage Investigations; S. J. Dennis, Refrigeration Technologist; G. H. Crawford, formerly Assistant Refrigeration Technologist; and G. W. Dewey and J. F. Fernald, of the Office of Horticultural and Pomological Investigations, were actively associated in the prosecution of these investigations.

83578°—24——1

eration would materially improve the carrying quality. In response to urgent requests from the industry, investigations of the relation of methods of handling and refrigeration to decay and deterioration of Puyallup Valley red raspberries in transit to distant markets were included in the fruit-handling and storage investigations of the Bureau of Plant Industry. Experimental work was carried on during the shipping seasons of 1911 and 1912, and to a limited extent during the season of 1913. Red raspberries were used in experimental work almost exclusively, although occasional lots of loganberries and strawberries were included during the season of 1911.

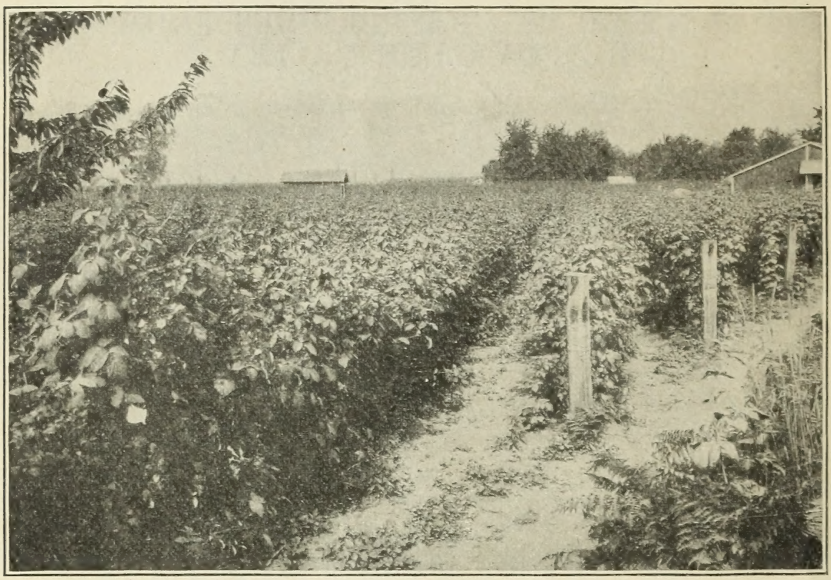

FIG. 1.—A red-raspberry yard at Puyallup, Wash.

THE BERRY INDUSTRY OF THE PUYALLUP VALLEY.

The methods of handling red raspberries are so closely associated with those of growing and of training that it seems desirable to give a brief description of the berry industry in the Puyallup Valley, Wash.

The berry industry in this valley is centralized largely around Puyallup and Sumner, in Pierce County, in the Puget Sound country of western Washington. The region is one of abundant rainfall, relatively cool summers, and mild winters, and originally was covered with forests of gigantic evergreens. The rains are most abundant during the winter months but are frequent during June, July, August, and September, and are one of the principal factors that determine the season's fresh-fruit shipments. If rains are continuous or frequent, with little or no sunshine, the berries do not mature properly, lack firmness, are soft and full of moisture, and consequently are poor shipping fruits. During 1911 practically all of the red raspberries produced in the valley could have been shipped fresh,

as there were few rains and much dry, sunshiny weather. In 1912 about half the crop was shipped fresh, the remainder, being too soft for shipment in a fresh state, being put up in barrels and cans.

During the season of 1912 the Puyallup and Sumner Fruit Association, then handling approximately 95 per cent of the berry crop of the valley, shipped 270 cars of fresh berries of 545 crates each. Of these 123 were red raspberries, 72 blackberries, 35 strawberries, and the remainder currants, loganberries, gooseberries, etc. The cannery receipted for 1,251,630 pounds of red raspberries, 3,424,874 pounds of blackberries, and 318,000 pounds of strawberries.

The two principal commercial varieties of red raspberries are the Cuthbert and the Antwerp. Of the blackberries the Evergreen, Snyder, Kittatinny, Lawton, and Himalaya are the leading varieties.

FIG. 2.—Red raspberries at Sumner, Wash., planted in rows, showing the separation of new canes from those in bearing, in order to facilitate picking.

The Cumberland black raspberry, the loganberry (a hybrid between the Antwerp red raspberry and the Aughinbaugh blackberry), and the Phenomenal (similar to loganberry) are grown to some extent.

The recent remarkable growth and development of the industry in this valley is due largely to the formation and successful operation of an effective cooperative marketing association. This association some years ago purchased a cannery, which is now operated as part of the cooperative enterprise. This plant has been greatly enlarged and improved, and more recently a second one has been built. These cooperatively owned canneries serve as the balance wheel of the berry-growing industry in the section. Without them the growers would be in a very precarious state, as through these canneries they are able to dispose of all berries that for various

reasons can not be shipped fresh at a profit. During periods following protracted rains, when berries are too soft for shipping, they are utilized for canning purposes and are not a total loss to the grower, as would necessarily be the case without canning facilities. The association has over 1,500 members, with individual plantings ranging from a few plants on a city lot to 15 or more acres.

The average berry yard consists of a few acres planted to different varieties of berries, usually half or more planted to red raspberries.

METHODS OF GROWING RED RASPBERRIES.

There are almost as many different ideas of how the red raspberry should be planted, pruned, and trained as there are growers. The most common practice in the Puyallup-Sumner district at the pres-

FIG. 3.—Red raspberries at Puyallup, Wash., grown in continuous rows in accordance with the upright system of training.

ent time is to plant in rows from 6 to 8 feet apart, either in continuous rows with the plants a few inches apart or in hills 1½ to 3 feet apart in the row. (Figs. 1 and 2.) The hills in each row may have three to nine canes, depending upon the strength of both soil and cane and the grower's preference. The hill system, with plants in hills about 6 feet apart each way, is occasionally used, but is becoming obsolete.

Where grown in rows, the methods of training and pruning may be roughly classed under four systems, as follows: (1) Upright, (2) weaving, (3) divided row, (4) Streblow. While there are many others, those mentioned or modifications of them are more often employed and have been found to be most practicable and profitable.

In the upright system, as illustrated in Figures 3 and 4, the old canes are trained between the wires which serve to hold them to-

gether and in place. The new canes come up among the old ones or else grow on the ground. The posts which support the wires are about 7 feet in length, set 5 feet above ground at from 30 to 50 feet apart. In this and other systems the wires may be attached directly to the posts or to crosspieces or arms, the wires being all the way from 10 to 16 inches apart. Either one or two sets of wires are used, the top wires being placed from 4 to 5 feet from the ground, the second set from 24 to 30 inches.

The weaving system may be used with either one or two sets of wires. Where two are used the old canes are wound three or more at a time along one of the top wires, the lower wires being used to hold the new canes in place and out of the way of the old ones.

FIG. 4.—Red raspberries at Sumner, Wash., trained in accordance with the upright system. All surplus canes have been cut out of the hills and all remaining canes topped.

There are a great many variations in this system, from those having only one wire along which to wind the old canes and with none to hold the new ones off the ground and free from the old canes to another method where the canes are not woven in as above described but are arched over the top wire two or three at a time and tied to the lower wire, the lower wires in such cases being about 48 inches and the top wire 60 inches from the ground. Several variations in the weaving system are shown in Figure 5, where the canes are all woven together three or more at a time along the top wire, in Figure 6, where they are woven in a similar way except that they are tied again to the adjoining canes, and in Figure 7, where they are wound over a top wire and tied to a lower wire.

In the divided-row system the wires are arranged essentially the same as in the upright continuous-row system, with the top wires at 5 feet from the ground. The old canes are separated and half of them tied or otherwise held in place along one wire and the remaining half tied to the other wire, leaving space between the wires for the new canes. This system, in a way, has several advantages, in that topping can be practiced and the new canes can be held separate and free from the old canes, permitting easier picking and harvesting. One good way of holding the canes in place is to bring the old canes outside the top wire and then to have loose wires outside of these which can be lifted into slots just above and slightly out from the original wires in such a way that the canes are held between the two. This system is illustrated in Figure 8.

In the Streblow system the rows are usually about 8 feet apart, running north and south, with hills 30 inches apart in the row. The

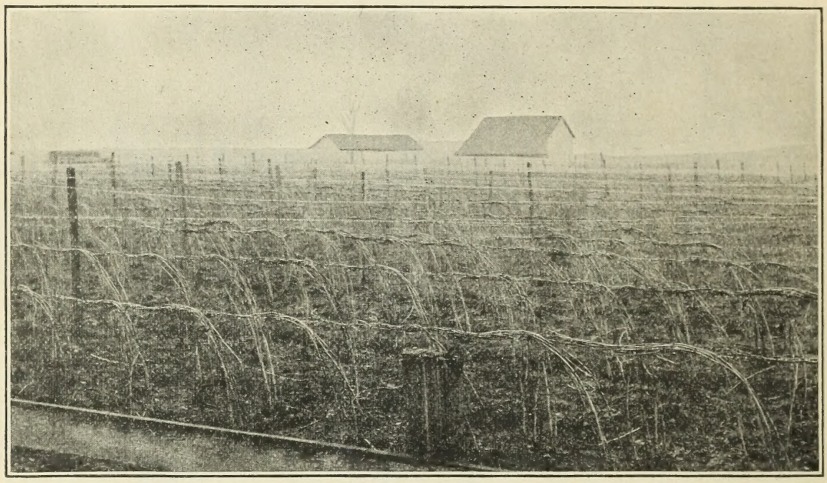

FIG. 5.—Red raspberries trained in accordance with one of several systems in use at Sumner, Wash. Topping is not practiced in this system.

posts are set solidly just to the east of the row. A wire is fastened to the post about 40 inches from the ground on the side toward the row and another wire about 52 inches from the ground on the east side of the post. The old canes are securely tied to the lower wire at 3 or 4 inches apart. The upper wire supports the weight of the canes when loaded with foliage and berries. The canes are topped at about 6 feet. A second wire, about 40 inches from the ground, is strung on crosspieces or on the posts on the west side of the row and serves to hold the new canes free from the old ones and off the ground. This system has some advantages, in that the canes can be cared for very easily after they are once tied in place and the bearing canes are all on one side of the row, where picking is easy and unhampered by new canes. The canes also lean toward the east, which is considered desirable, and at picking times they shade both fruit and pickers. This system, however, requires more work in training. The rows must be farther apart, and some claim that the

yield is somewhat reduced because of the smaller number of canes per acre. The heavy weight on one side of the post makes it necessary to set the posts deeper or closer together than in other systems. Where hop poles or rails are available at a low cost they are often used in place of the upper wires, the rails bearing the weight of the loaded canes thus providing a larger surface and reducing the danger of having the canes break at this point. The Streblow system is partially illustrated in Figure 9. In this case rails are used instead of wires.

There is also considerable diversity of practice as to topping and cutting out old canes. Some growers cut out the extra canes in the

FIG. 6.—Red raspberries trained in accordance with a modification of the weaving system, at Sumner, Wash. The canes, after being bent over and twisted around the top wires, are tied to adjoining canes below the wires.

fall; others leave them until spring. In most cases the canes that are left are topped to about 5 or 6 feet in the spring, in the systems of training that permit topping. In some of the weaving systems topping is obviously out of the question. The soil is given rather shallow cultivation during the growing season and the fields are kept clean of weeds until picking time. Nearly all growers fertilize rather heavily, using manures of various kinds in addition to moderately heavy applications of potash. There is a general belief that potash makes the berries firmer and betters the keeping and shipping quality, and therefore this one element is seldom omitted.

Before the harvesting season commences the growers usually go through the patches and cut out a considerable portion of the new

canes and separate the bearing canes from the new ones in order to facilitate picking. The harvesting of berries is facilitated also to a considerable extent by various methods of training, some of which have already been described. Proper training methods, the cutting out of surplus new canes, and the separation of the remaining ones from the bearing canes prior to harvesting greatly lessen the liability to rough handling and injury in picking.

HANDLING AND SHIPPING RED RASPBERRIES.

The first shipments of red raspberries are usually made about the middle of June, but car-lot shipments are seldom made until the latter part of June or the first of July. The earlier berries are shipped

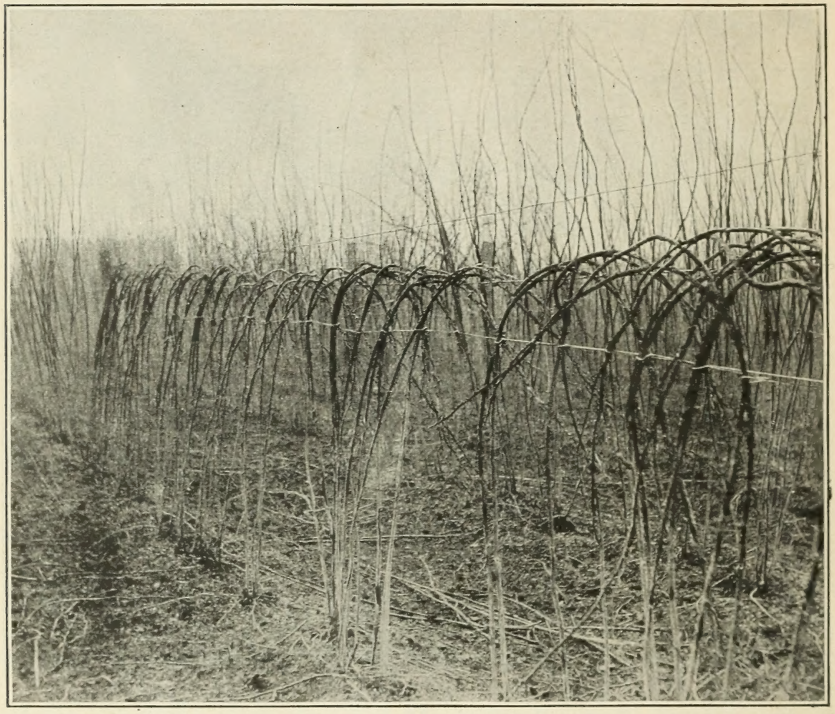

FIG. 7.—Red raspberries trained in accordance with a modification of the weaving system, in which topping can be practiced if found to be desirable. The canes are looped over the top wire and tied to one lower down.

by express, either in crates to near-by cities or in pony refrigerators to Spokane and Montana markets. Later in the season, when carload shipments commence, usually only such markets as Spokane and others within about the same distance are supplied with raspberries in these pony refrigerators. The berries shipped in this way during the car-lot season are, as a rule, too ripe to stand long-distance shipment.

PICKING.

The picking is done by men, women, and children, most of whom come from neighboring towns and cities and camp during the har-

vesting season in the various yards where they are doing the picking. They usually remain until the end of the blackberry season, sometime in September. Some of these people return from year to year, but most of them have had no previous experience. This results in some very poor work as regards both sorting and handling. Each picker is provided with a 2-cup carrier attached to the waist and when the cups are full they are transferred to 6-cup field carriers provided with handles. (Figs. 10 and 11.) These 6-basket carriers when filled are carried to the receiving sheds, where the berries are sorted and crated. (Fig. 12.) Usually each picker is assigned to a particular row or rows and is held responsible for the harvesting of a certain portion of the row or yard. A foreman or the grower

FIG. 8.—Red raspberries trained in accordance with the divided-row system, the canes being tied to wires on either side or held in place by an outside wire. Topping may be practiced, if desired.

supervises the picking, instructing each picker as to the kind of berries to be picked and how to pick them. At the receiving shed the grower or receiver does more or less sorting by cups, placing the cups containing what are considered shipping berries into shipping crates and cups with berries too ripe for shipping into cannery crates. The shipping quality is determined by the appearance of the fruit in the box as regards its degree of ripeness and firmness, the fruit never being emptied out for resorting or grading. The final determination of the shipping fruit is, however, made by the association inspectors, and it is not unusual for berries put in shipping crates by the grower to be rejected and sent to the cannery when inspected at the association receiving station.

HAULING AND DELIVERY.

The berries are nearly all delivered at Puyallup or Sumner, a small proportion at North Puyallup, Auburn, and other stations. They are seldom hauled more than 6 miles, and the greater portion less than 3. The wagons used for hauling are of various sizes and types, depending on the quantity of berries and the distance they have to be transported. Large drays provided with good springs are oftentimes used to haul berries from considerable distances for several growers. Usually each grower hauls his own berries, and in nearly every case wagons or carts with springs are used for hauling. Many of the growers living within the city limits or close by take their berries to the canning or receiving stations in 2-wheeled hand carts. Figures 13 and 14 give a good idea of the different

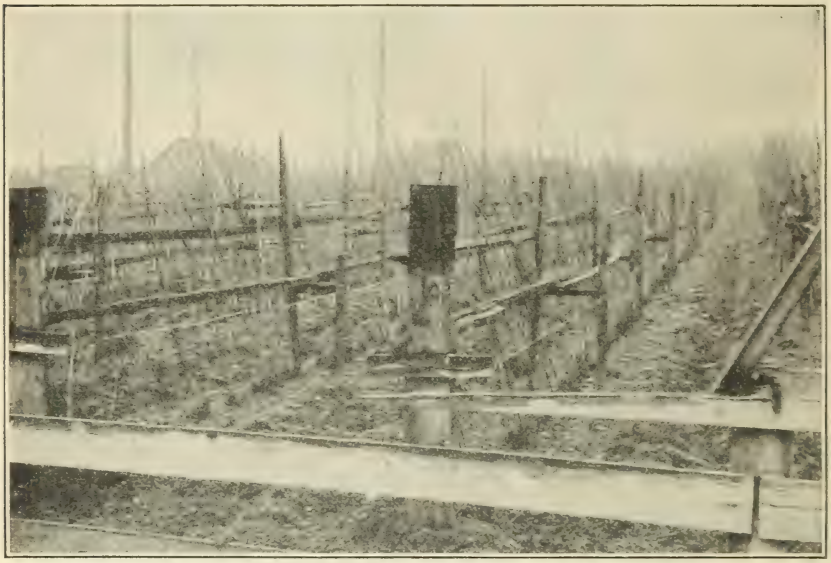

FIG. 9.—A yard of red raspberries trained in accordance with the Streblow system, using rails instead of wires for holding the bearing canes.

types of wagons and carts used for hauling berries to the cannery and receiving stations. Deliveries are made oftentimes three or more times a day from near-by growers, but usually only once by the more distant ones. Every grower aims to bring all the berries picked during the day to the receiving stations in time to be loaded into the refrigerator cars for shipment on the evening of that day. Each grower is known by a number, which must be stamped on all shipping crates brought in, and all berries delivered are credited to his number, shipped berries by number of crates and canning berries by weight.

These practices are expensive of time and equipment and suggest the need of a cooperative plan for hauling the product. It seems practicable to devise an effective plan which would conserve the time of the grower as well as simplify the work at the receiving station.

GRADING.

Berries intended for shipment are inspected before they are loaded into the car and are separated into various grades, the grading being based on their degree of maturity, firmness, and the care shown in picking. (See fig. 15.) The berries run fairly uniform throughout the crate, and the inspection is made by lifting up one end of the cover and deciding on the general condition of the berries as they appear in the top layer. There are four established grades, as follows:

FIG. 10.—Picking red raspberries at Sumner, Wash. Note the rank growth of new canes.

D.—Stock that can be shipped 2,000 miles or more.

M.—Stock of such character and maturity that it can be safely shipped more than 1,000 miles.

H.—Stock which because of faulty handling or overripeness must be consumed in 24 hours. Such stock is used for local express shipments in pony refrigerators to near-by points.

A.—Stock too soft and ripe for anything but canning.

SHIPPING AND MARKETING.

Red raspberries and other berries from this section are shipped by express in crates to near-by cities, like Seattle, in pony refrigerators to markets as far distant as Spokane, Wash., and Missoula, Mont., and in full carload lots in express refrigerator cars as far east as Minneapolis, Minn. Before and after the car-lot season, pony refrigerators are shipped to a greater number of markets and to greater distances than during the car-lot season. When berries are shipped in crates, not in carload lots, no refrigeration is possible in

transit, and this necessarily limits the distance to which they can be shipped in good condition. The crate ordinarily used holds 24 cups in 2 layers of 12 baskets each, and has a middle partition board. The removable veneer used to separate the top and bottom tiers is fitted into notches cut into the end and middle partition. The pony refrigerator used in this section holds 54 cups in 6 layers of 9 cups each. (See fig. 16.) An ice pan, with drainage, is placed in the top of the carrier, the refrigeration provided being in proportion to the capacity and the quantity of ice in the ice pan. This method of shipment is utilized throughout the season to supply markets at a considerable distance that can not handle full carload lots and that can not be reached without the utilization of refrigeration.

FIG. 11.—Picking red raspberries at Sumner, Wash., in a yard in which the new canes have been gathered together in the middle of the row in order to facilitate picking operations.

During the main part of the season most of the berries are shipped in express refrigerator cars. These cars are attached to regular fast passenger trains and go through on passenger schedules. The cars are fully iced at least 12 hours before loading, and after they are fully loaded from 100 to 200 pounds of salt is mixed in with the crushed or broken ice in each bunker. At icing stations the cars are re-iced and may also be resalted. While salt melts the ice more rapidly, it supplies more refrigeration than would be the case if no salt was used. Every effort is made to get all of the fruit of a day's picking into refrigerator cars as soon as possible and to start the cars on the same day or evening that the berries are picked and loaded. The standard load for all except Canadian points is 545 crates, loaded 8 and 9 high in rows of 5 across the car. The load is well cleated and braced in the center, so that there is seldom any shifting or breakage in transit. The carload shipments are sent to

Butte, Helena, and Billings, Mont., and to points in North Dakota and South Dakota, such as Fargo, Grand Forks, and Aberdeen, as far east as Lincoln, Nebr., and Minneapolis, Minn., and to such Canadian points as Winnipeg, Calgary, Edmonton, Regina, and Moosejaw.

Nearly all of the berries in the valley are marketed through the association, there being very few growers who are not members. All of the berries that are not shipped are turned in to the cannery, the association paying a uniform price to its members, determined after the running expenses and the selling prices are known. During

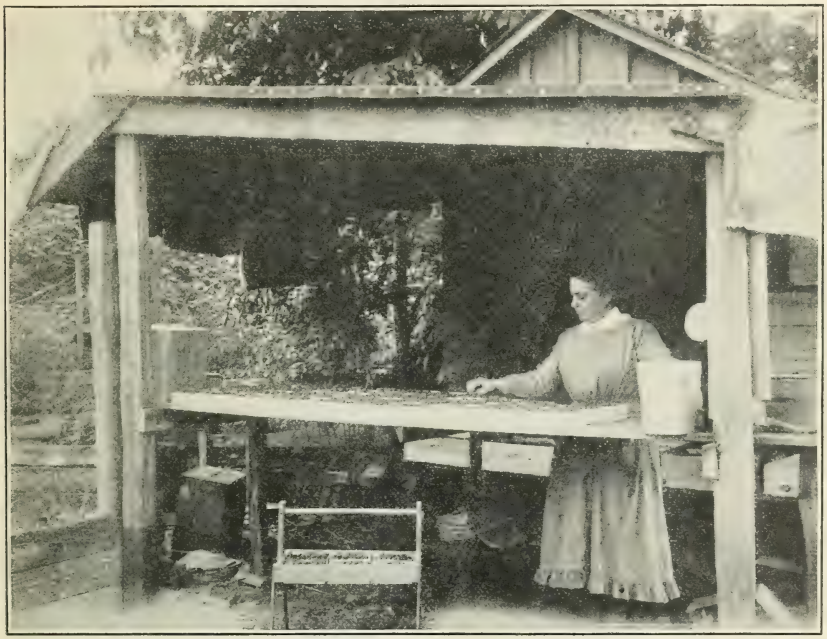

FIG. 12.—A receiving shed at Puyallup, Wash., where berries are sorted by cups into shipping and canning crates.

the season of 1912 a considerable quantity of the fruit turned in to the cannery was put up in barrels. Practically no berries are evaporated in this section.

CAUSES OF DECAY OF FRUIT IN TRANSIT.

The most common causes of decay of berries in transit and after arrival on the market are mold fungi, principally gray or black mold (Botrytis) and blue mold (Penicillium). Neither of these two fungi seriously attacks firm, sound berries, but they quickly attack and cause the decay of berries injured or bruised in handling or soft from being overripe. Investigations with less tender and perishable fruits, such as oranges, apples, pineapples, lemons, and the like, have demonstrated that there is a direct relationship existing between the type of handling given the fruit and its behavior after picking, in transit, and after arrival on the market. The results of the work

with berries are fully consistent with the general principles underlying the relationship between methods of preparing the fruits for shipment and their behavior in transit and on the market. The methods of handling red raspberries in picking and in shipping determine the condition of berries on the market fully as much as does handling in the shipment of oranges.[2] In the handling of red raspberries three factors primarily determine the amount of decay and the condition of the berries on the market: (1) Injuries in handling; (2) sorting as to ripeness; (3) promptness and rapidity of cooling.

INJURIES IN HANDLING.

The most common injuries result from carelessness in picking the berries from the vines, by breaking or bruising them when pulling

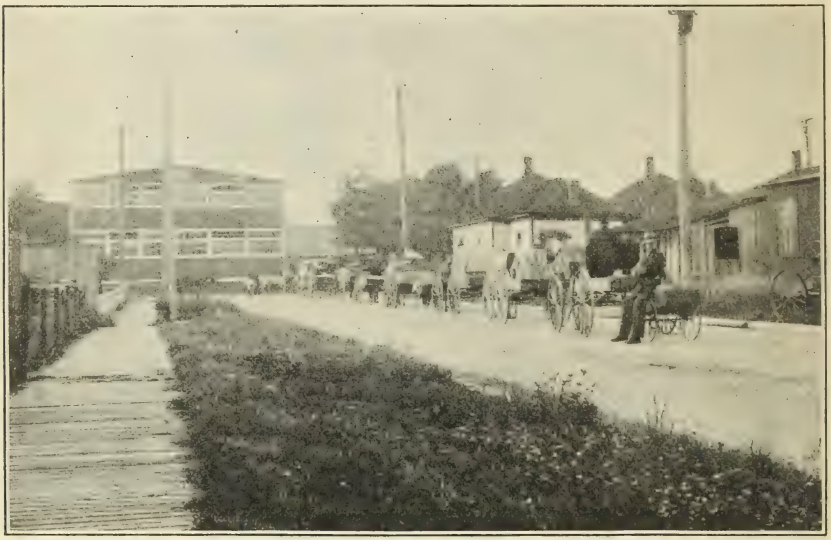

FIG. 13.—Growers waiting in line at Puyallup, Wash., to deliver the day's pick of red raspberries at the cannery or receiving station. Note the various types of wagons and carts in use.

them away from the receptacle and by mashing them in the hand before placing them in the cups. In inspections on the market it is a very common thing to find cups containing masses of decay easily traceable to berries mashed in the hand of the picker before being placed in the cup. Serious injury and decay also result from attempts by pickers to sort over filled or partly filled cups.

The injury and decay that result from breaking the berry or bruising it when pulling it away from the receptacle is probably the most common and serious. This injury can be avoided almost entirely by using three fingers instead of two and by pulling the berries off straight rather than sidewise.

---

[2] Stubenrauch, A. V., Ramsey, H. J., and others. Factors governing the successful shipment of oranges from Florida. U. S. Department of Agriculture Bulletin No. 63, 50 p., 1914.

Powell, G. Harold, and others. The decay of oranges while in transit from California. Bureau of Plant Industry Bulletin No. 123, 79 p., 1908.

Three fingers distribute the pressure more evenly and greatly lessen liability from injury, provided no more pressure is applied than is necessary to separate the berries from the receptacle.

SORTING AS TO OVERRIPENESS.

One of the most common causes of decay and deterioration is carelessness in sorting berries into their proper grades at the time of picking. Berries intended for long-distance shipment must be at as nearly the same stage of development as possible, with none overripe or soft at the time of picking. Every grower knows when a berry is in ideal condition for long-distance shipment and strives to have his pickers exercise precaution and care to place only sound, uninjured, unbroken, properly matured berries in the cups.

FIG. 14.—Delivering red raspberries at the receiving station at Puyallup, Wash., types of vehicles ranging from carts to large drays and express wagons being used for hauling.

This practically means removal of the berries from the vines as quickly as they will slip off the core. Overripe and soft berries when mixed with the properly handled and properly matured ones cause the spoilage of the whole cup and reduce the value of the whole crate. A soft berry will soon break down; molds will gain entrance and not only cause the decay of the single berry but spread throughout the cup. Too much emphasis can not be placed on faultless sorting.

PROMPTNESS AND QUICKNESS IN COOLING.

Apparently the ripening processes of red raspberries continue very actively after the fruit is removed from the vine, and especially if the temperatures are relatively high. To arrest the physiological activities which constitute ripening, to retard and prevent the germination of mold spores, and to retard the development and growth

of mold fungi, it is essential that the berries be promptly and quickly cooled after picking. The picked berries lose much of their life by standing in the sun after picking and by delay in getting them into a refrigerator car. The necessity of prompt and quick cooling will be more fully discussed later.

OTHER INJURIES.

Considerable injury also occurs in hauling over rough roads or on springless wagons and in rough, careless handling to and from the wagon in such a way that the berries roll around in the cups, becoming injured, mashed, and broken. The same applies to handling in the car or in pony refrigerators. A pony refrigerator (fig. 16), when being loaded into an express car, is often tilted at such an angle and so violently jolted that berries are badly mashed and injured by rolling around in the cups. Much greater care could easily

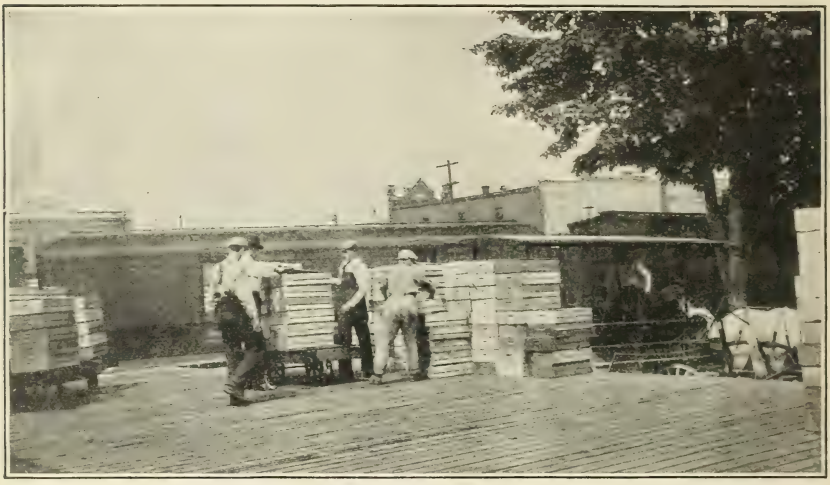

FIG. 15.—Inspecting red raspberries on the platform at Puyallup, Wash., before loading them into a refrigerator car.

be exercised even in such a hurry-up job as loading express shipments. Rough, uneven loading platforms are also the cause of considerable injury as the fruit is trucked to the car.

FREQUENCY OF PICKING.

It is customary to pick a patch over once a day, although patches are frequently left two or three days. The pickings should be made sufficiently close together to avoid having any considerable proportion of overripe berries. Overripe berries are usually sent to the cannery, but a lot of such berries in a patch makes it extremely difficult to obtain good and proper sorting, the result being that a great many good shipping berries with a few overripe ones in them are sent to the cannery or else are shipped, with the inevitable decay and poor returns as a result.

RELATION OF RAINFALL TO HANDLING.

The climatic conditions during a season to a great extent determine not only the shipping quality but also the quantity shipped in a fresh state. During wet, rainy periods it is impracticable to pick berries. Much fruit becomes overripe, and if the rainy weather continues for any length of time all the berries will lack the desired firmness, being soft, very tender, and full of moisture. The rains therefore determine largely the fresh-fruit output and are a big

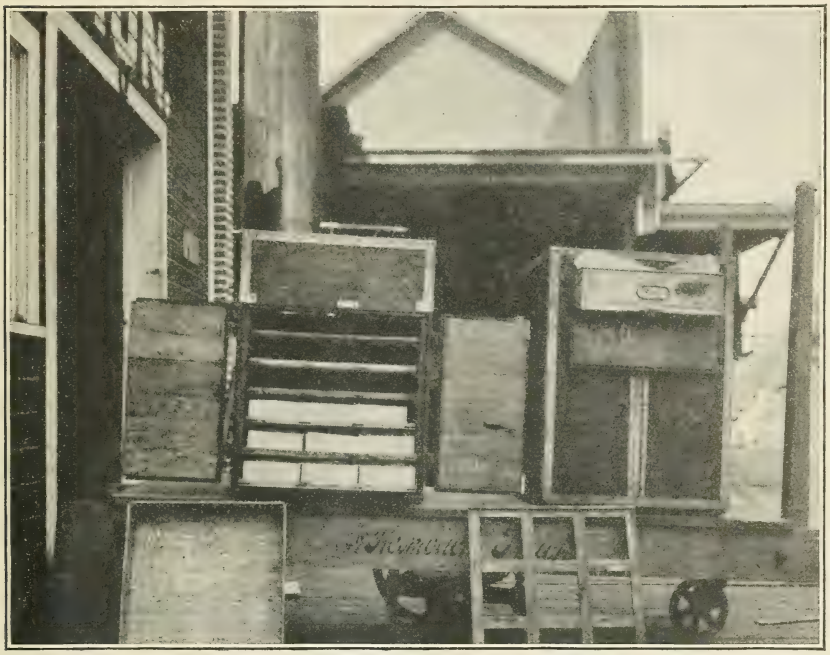

FIG. 16.—A pony refrigerator used for the shipment of small lots of red raspberries under refrigeration. The open refrigerator shows six compartments, three of which are filled.

factor in the success attained during any one season. Many berries mold on the vines during muggy weather, and all the berries are so extremely tender as to stand practically no pressure or handling without injury.

RELATION OF METHODS OF GROWING TO KEEPING QUALITY.

The liability to injury in handling depends to some extent also on the methods of growing and training. The visible evidence in the valley seems to indicate that potash used with judgment tends toward firmer and better keeping berries. This statement is not based on any experimental evidence, but only on a general existing belief among the better growers and on observation during the two seasons covered by this work. It is, of course, unnecessary to consider all those factors in culture that tend to produce first-class fruit. The

desirability and advantage of high quality are unquestioned. Much can be done in training to reduce the liability to injury, especially at harvest time. It is customary to cut out the greater portion of the nonbearing wood, leaving only sufficient to allow for a good selection of canes for next year. The remaining nonbearing canes are oftentimes sorted out from the others and tied to a separate wire in order to facilitate picking. This enables the pickers to get at the berries more easily, lessens the liability of leaving berries that should be picked, and makes it possible to do the picking with more care.

THE LABOR PROBLEM.

The fact that much of the picking is done by help which has had no previous experience necessitates a great deal of painstaking work on the part of the grower and foreman in instructing the pickers in proper methods and in seeing that they follow instructions. Until the labor becomes thoroughly trained the picking may be anything but that desired or necessary for the best results. A great many of the pickers are children, and it is almost impossible to impress upon them the reason or necessity for careful handling and to imbue them with the proper feeling of responsibility. Aside from other considerations, the fact that the pickers are paid almost entirely on the basis of quantity makes the problem of securing proper care in handling even more difficult.

HANDLING, AN ECONOMIC PROBLEM.

The problem of handling is one of great economic importance and equally as momentous as that of growing. The fullest measure of success can come only to those who, after producing the finest fruit possible, successfully solve the problem of handling so as to insure the maximum carrying quality of the fruit. To overcome the losses in transit and to broaden the marketing territory are strictly business propositions related to methods of organizing the berry business, to systems of hiring labor, to methods of picking, hauling, and shipping, to methods of inspection at receiving sheds, and to the proper utilization of precooling and refrigeration. Any system of handling that puts a premium on quantity and not quality must necessarily be detrimental to the best interests of the industry.

CAREFUL-HANDLING EXPERIMENTS.

During the season of 1911 and 1912 a series of careful-handling experiments was made in order to determine the relation of the methods of handling to the decay and deterioration of red raspberries in transit and after arrival on the market. Each lot or series consisted of a number of carefully handled crates of raspberries with the same number of comparable commercially handled crates from the same yard and picked at the same time. During the season of 1911 it was found impracticable to make shipments, and therefore all lots were held in a fully iced refrigerator car, from which fruit was withdrawn after lapses of time representing transit periods of four, six, and eight days, respectively. The percentages of decay

were determined by carefully separating the moldy and soft berries from the sound ones, the percentages being based on actual weights of moldy, soft, and sound berries.

RESULTS OF THE HOLDING TESTS IN 1911.

The carefully handled berries held in a car for four days developed only 0.4 per cent of decay, while the commercially handled comparable lots developed an average of 4.6 per cent of decay. The berries held six days in a car developed even more striking differences, the carefully handled 0.2 per cent and the commercially handled 9.9 per cent of decay. At the end of eight days the carefully handled fruit had developed but 2.2 per cent of decay as against 26.7 in that commercially handled, or only one-twelfth as much. At the end of eight days the carefully handled fruit had developed only half as

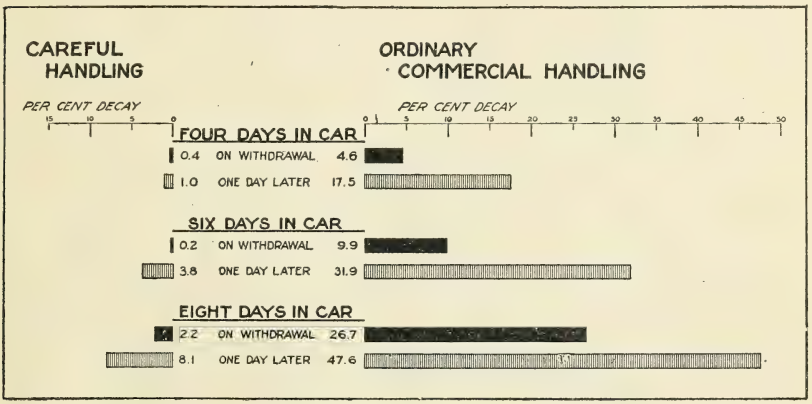

FIG. 17.—Diagram illustrating the percentage of decay in carefully handled and commercially handled red raspberries held in an iced car at Puyallup, Wash., for four, six, and eight days, on withdrawal and one day later, season of 1911.

much decay as that commercially handled in the car but four days. Figure 17 and Table 1 show the differences in decay due to differences in handling methods. Included under the term " decay " as used here are both soft and moldy berries. Under the first designation are included berries entirely too soft and mushy to be marketable for any purpose, but showing no mold.

The development of less decay in the fruit held in the car six days than in that held for but four days is an apparent inconsistency, but it is easily accounted for when one takes into consideration the fact that different lots of fruit must necessarily be used at each inspection. While the aggregate of fruit used in these investigations was large, the quantity of fruit inspected each time for any part of a single experiment or test was necessarily limited, and such slight discrepancies as occur in Table 1 and others usually result from occasional bad decay in a single cup or crate.

TABLE 1.—*Decay in carefully handled and commercially handled red raspberries held in an iced car at Puyallup, Wash., in 1911.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Carefully handled.	Commercially handled.	Carefully handled.	Commercially handled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	0.4	4.6	1.0	17.5
6 days	.2	9.9	3.8	31.9
8 days	2.2	26.7	8.1	47.6

MARKET-HOLDING TESTS.

One-half of the fruit from each withdrawal was held one day under ordinary market conditions and another determination of decay and deterioration was made. The result of these inspections is even more striking than of those made on withdrawal. This is self-evident when allowance is made for the extremely favorable conditions existing for the development of mold or deterioration when fruit is exposed to contact with warm air. Imperfections or injuries due to improper and rough handling, as well as overripe berries, offer the maximum conditions for spoilage. The carefully handled fruit held four days in the refrigerator car and one day after withdrawal developed 1 per cent of decay, the commercially handled 17.5 per cent. The after-withdrawal inspections of the 6-day lot showed 3.8 per cent of decay in the carefully handled and 31.8 per cent of decay in the commercially handled fruit, while similar inspections of the 8-day lots showed 8.1 per cent of decay in the carefully handled and 47.6 per cent in the commercially handled berries. Figure 17 brings out most strikingly these differences and the relation of handling to keeping quality.

From this showing it is safe to assume that fruit handled with the proper degree of care can be shipped fully twice the present distance, or a distance representing a haul of 4,000 miles, as against a 2,000-mile haul for ordinarily handled fruit. This assumption is further strengthened and the results in 1911 further corroborated by the results of the careful-handling work during the season of 1912, when a series of actual shipments was made to Grand Forks, N. Dak. The fruit held in the iced car at Puyallup the previous season was really under more favorable conditions than exist in a fully loaded refrigerator car, as the holding car was only partially filled and the rate of cooling of all lots was more rapid than in fully loaded cars. It was therefore deemed necessary to obtain some data from actual shipping experiments.

Great difficulty was experienced in procuring the desired number of cars consigned to any one market, but arrangements were made to place the experimental crates in cars destined for Grand Forks or routed through that point, opening the cars and withdrawing the crates in transit. The crates were transferred to an iced car held there, the transfer being made quickly after wrapping in thick canvas to protect the contents from contact with the warmer air and prevent a consequent condensation of moisture. The fruit was transferred to the refrigerator car and held for different lengths of time after arrival there, in order that conditions representing hauls of

approximately four, six, and eight days might be obtained. The period of transportation to Grand Forks was usually a little less than four days, and the fruit was quite thoroughly cooled in transit, so that the transfer to another iced car resulted in but slight change in temperature. The holding periods of two and four days in this car after arrival therefore gave conditions during transit periods of six and eight days. These periods correspond with the holding periods at Puyallup during the season of 1911.

SHIPPING TESTS DURING THE SEASON OF 1912.

Figure 18 and Table 2 show the results of these inspections and corroborate fully the results of the season of 1911.

The carefully handled fruit shows but 0.2, 0.8, and 2.7 per cent of decay at the end of four, six, and eight days, respectively, as against 3.9, 7.4, and 14.6 per cent of decay for the commercially handled

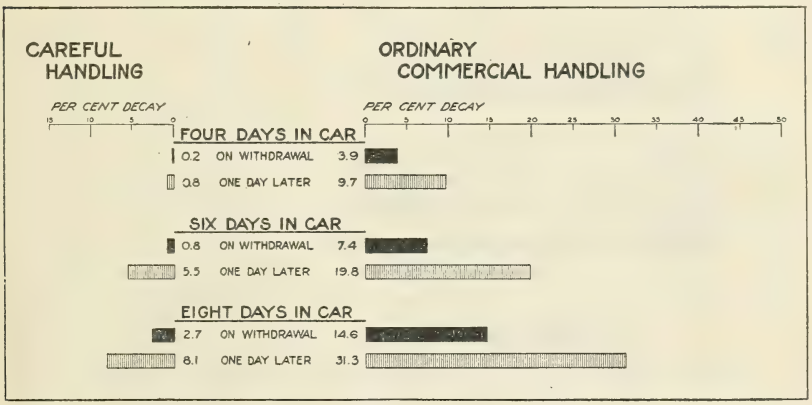
CAREFUL HANDLING
ORDINARY COMMERCIAL HANDLING
PER CENT DECAY
PER CENT DECAY
15 10 5 0
0 5 10 15 20 25 30 35 40 45 50
FOUR DAYS IN CAR
0.2 ON WITHDRAWAL 3.9
0.8 ONE DAY LATER 9.7
SIX DAYS IN CAR
0.8 ON WITHDRAWAL 7.4
5.5 ONE DAY LATER 19.8
EIGHT DAYS IN CAR
2.7 ON WITHDRAWAL 14.6
8.1 ONE DAY LATER 31.3

FIG. 18.—Diagram illustrating the percentage of decay in carefully handled and ordinary commercially handled red raspberries after arrival at Grand Forks, N. Dak. The decay shown under the heading "Four days in car" is that developed in transit from Puyallup to Grand Forks, and the decay shown under the headings "Six days in car" and "Eight days in car," respectively, represent additional holding periods in an iced car at Grand Forks of two and four days, making total transit periods of six and eight days.

berries for the same periods. The after-withdrawal inspections are equally striking. There was less decay (2.7 per cent) in the carefully handled fruit at the end of eight days than in that commercially handled at the end of but four days (3.9 per cent). These results so fully corroborate those obtained during the season of 1911 that further discussion is unnecessary.

TABLE 2.—*Decay in carefully handled and commercially handled red raspberries shipped to Grand Forks, N. Dak., in 1912.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Carefully handled.	Commercially handled.	Carefully handled.	Commercially handled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	0.2	3.9	0.8	9.7
6 days	.8	7.4	5.5	19.8
8 days	2.7	14.6	8.1	31.3

WHAT CONSTITUTES CAREFUL HANDLING.

In view of the superior carrying qualities of the carefully handled fruit and the marked advantage that its better market-holding properties give it, it may well be asked, What constitutes careful handling? This can best be answered by a description of the methods used in picking the specially and carefully handled lots.

Special care was taken to remove the berries from the bushes without breaking or crushing them and to place each berry in a cup immediately, in order to avoid mashing it in the hand. Bruising in picking can be avoided to a great extent by using three fingers on each berry instead of two. When only two fingers are used, the pressure is concentrated at two points on the berry, while the use of three fingers distributes the pressure more evenly and very greatly lessens the liability to injury, provided no more pressure than is necessary is used to separate the cap from the receptacle. Great care was exercised to place all overripe berries in separate cups and to put none but sound, unbroken, uninjured, and properly matured berries into cups and crates intended for long-distance shipment. Berries may be considered properly matured as soon as they will slip off the core without breaking. The frequency of picking also is a factor in careful handling. Proper handling, as above described, is comparatively a simple matter where the pickings are made sufficiently close together to avoid having an undue proportion of overripe berries in the yard. If a grower gets behind in the picking, careful handling is much more difficult of accomplishment, owing to the great quantity of "overripes." The filled crates were hauled to the receiving station or car in spring wagons and covered with canvas to protect the fruit from the sun and dust. Previous to loading, the crates containing the fruit were kept in the shade of a receiving shed and exposed as little as possible to the sun after removal from the vines. When loading on and unloading from the wagons and when placing in the car the crates were handled with all possible care, especial effort being made to keep them in a horizontal position and to prevent hard jolting in placing them on the platform or in the car. The too frequent practice of tipping crates nearly on end in loading cars results in considerable bruising, as the berries roll from side to side in the cups and against the division board and the cover.

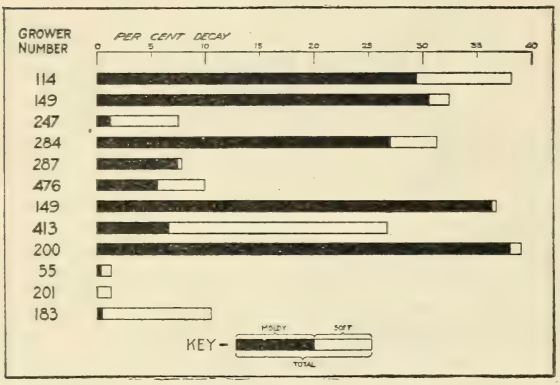

FIG. 19.—Diagram illustrating the percentages of moldy and of soft fruit and total decay in commercially handled fruit obtained from various growers, this fruit being held in an ordinary iced car for four days at Puyallup, Wash., in the season of 1911.

That the berries can be handled commercially with sufficient care to insure the desired keeping quality is not seriously questioned by

intelligent growers. It is largely a matter of the thorough organization of their forces, proper instruction in methods of handling, constant supervision, and careful inspection of work. That many growers are already accomplishing the work as well or better even than did the workers of the Bureau of Plant Industry is indicated in Table 3 and Figure 19, which show the percentages of mold, soft berries, and total deterioration in the first inspection of fruit from 12 different growers. The decay runs from 1.3 per cent to 39 per cent.

TABLE 3.—*Moldy and soft berries and total decay in commercially handled lots of red raspberries from different growers held in an iced car at Puyallup, Wash., in 1911.*

Grower No.	Moldy.	Soft.	Total decay.	Grower No.	Moldy.	Soft.	Total decay.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
114	29.5	9.0	38.5	149	36.4	0.4	36.8
149	30.6	1.8	32.4	413	6.7	20.0	26.7
247	1.3	6.2	7.5	200	38.0	1.0	39.0
284	27.1	4.2	31.3	55	.4	.9	1.3
287	7.4	.4	7.8	201	.1	1.2	1.3
476	5.6	4.3	9.9	183	.5	10.0	10.5

These men paid their pickers the same wage. The great differences noted were due mainly to the character of the work required by the owner from his help. These figures emphasize most strongly the need of closer supervision of the picking by the association. If all the handling operations could be brought up to the standard of the better ones shown in the above table, the carrying quality and reputation of the fruit would be greatly enhanced, the markets could be greatly extended, and more remunerative prices could be obtained.

EFFECT OF DELAY IN COOLING ON KEEPING QUALITY.

Nearly everyone recognizes the need for the prompt cooling of fruits intended either for shipment or storage, particularly such tender fruits as red raspberries, which ripen very rapidly after removal from the vines, especially if the temperatures are relatively high. To demonstrate the effect of delay in cooling on red raspberries, a certain number of crates from each series during the 1911 season were not placed in the refrigerator car until the afternoon of the following day. Table 4 and Figure 20 bring out strikingly the results.

TABLE 4.—*Decay in commercially handled red raspberries following immediate and delayed loading at Puyallup, Wash., in 1911.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Immediate.	Delayed.	Immediate.	Delayed.
4 days	7.1	27.7	18.3	39.5
6 days	16.9	38.7	28.3	54.5
8 days	30.2	50.4	43.5	62.1

A comparison of the figures and diagrams should be sufficient. The immediate lots showed 7.1 per cent of decay as against 27.7 per cent of decay in the delayed lots of the same fruit after four days

in the car. At the second inspection, after six days in the car, the immediate lots had 16.9 per cent of decay as against 38.7 per cent of decay for the delayed berries, and at the end of the 8-day period the immediate lots showed 30.2 per cent of decay as against 50.4 per cent of decay in the delayed fruit. The inspections one day later are equally striking and convincing. These results emphasize further the importance of protecting the fruit after picking from undue exposure to the sun and of getting it under refrigeration quickly.

PRECOOLING EXPERIMENTS.

In the precooling experiment with red raspberries at Puyallup during the season of 1911, it was not possible to combine the careful-handling investigations with precooling. The precooling tests included, therefore, only commercially handled lots. The precooling was accomplished by means of the portable ammonia plant of the

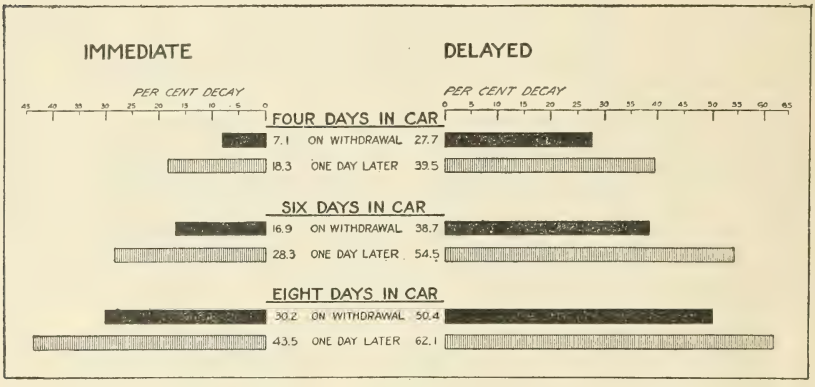

FIG. 20.—Diagram illustrating the percentage of decay in red raspberries of immediate and delayed loading, season of 1911, representing comparable lots of fruit, the immediate loaded as soon as brought in from the field, the delayed held over until the next day before being placed in the refrigerator car. Both lots were held in an iced car at Puyallup, Wash.

Department of Agriculture, both before and after loading the fruit in the cars. For the warehouse precooling test—cooling before loading—a refrigerator car was used as a warehouse cooling room by putting in a false floor and ceiling, and the fruit loaded into the car was cooled by forcing the cold air from the precooling plant under and through the false floor and the fruit. After cooling, the fruit was transferred into another pre-iced refrigerator car for shipment, the loading being done through a canvas hood to protect the fruit from contact with the warm outside air. Only a few tests were made with this outfit.

Most of the precooling tests were made with fully loaded cars, the cold air being forced in one bunker through the fruit and taken out at the other bunker and back to the plant for recooling. It was not practicable to obtain inspections at the market end, and therefore marked crates from the precooled cars, together with check crates of the same fruit nonprecooled, were held in an iced car for four, six, and eight days. In most cases the average temperatures of the fruit in the precooled cars were reduced to about 40°, the initial temperatures being often above 70° F.

The results of this work, while decidedly beneficial in most respects, emphasize strikingly, as in the case of many other fruits used in similar tests, that precooling can never be depended upon to accomplish nearly as much as careful handling. While precooling proved decidedly beneficial, it did not in any measure overcome the bad effects of rough, careless, and improper handling. The most noticeable feature of the precooling was the improved appearance of the precooled berries, which were decidedly brighter and fresher than those held without precooling.

PRECOOLING EXPERIMENTS IN THE SEASON OF 1911.

The inspections were made in the same way as those described for the careful-handling investigations. Table 5 and Figure 21 give the results of the precooling work during the season of 1911.

TABLE 5.—*Decay in commercially handled red raspberries that were immediately loaded and held in an iced car with and without precooling.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Precooled.	Nonprecooled.	Precooled.	Nonprecooled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	2.2	5.9	9.5	16.5
6 days	9.1	15.4	19.1	34.8
8 days	17.2	27.3	36.0	45.1

Precooled, immediately loaded, commercially handled berries showed 2.2 per cent of decay and the nonprecooled 5.9 per cent of decay at the end of the 4-day period, and 9.1 per cent of decay and 15.4

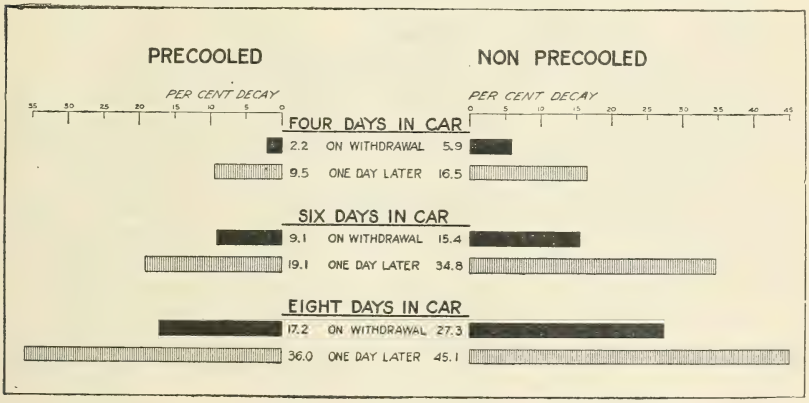

FIG. 21.—Diagram illustrating the percentage of decay in comparable precooled and nonprecooled commercially handled red raspberries held in an iced car, season of 1911, at Puyallup, Wash., for four, six, and eight days.

per cent of decay, respectively, at the end of the 8-day period. The after-withdrawal inspections are consistent with the withdrawal results. The ratio of percentages of decay is much the same at the end of the 4-day period (9.5 per cent of decay in the precooled and 16.5 per cent of decay in the regular iced) and at the end of the 8-day period (36 per cent of decay in the precooled and 45.1 per cent of decay in the nonprecooled). These data, while emphasizing

the beneficial effects of precooling, bring out most strongly the importance of careful handling.

PRECOOLING EXPERIMENTS IN THE SEASON OF 1912.

During the season of 1912 the precooling investigations were continued, and carefully handled as well as commercially handled berries were used. The fruit was shipped to Grand Forks, N. Dak., as in the case of the handling investigations previously noted. Unfortunately, owing to market conditions a number of precooled and check cars were diverted and did not reach the inspection point. The data, while not as comprehensive as desirable, are nevertheless consistent with the results of the 1911 season and are considered sufficiently conclusive to warrant final deductions being made.

As in the season of 1911, more beneficial results were obtained from careful handling than from precooling alone. The results, however, bring out clearly the fact that precooling with proper handling is of great service and value in the preservation of fruits like red

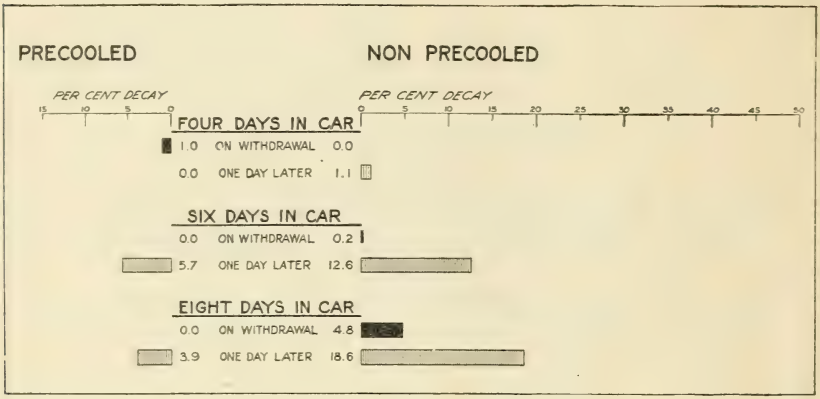
PRECOOLED
NON PRECOOLED
PER CENT DECAY
PER CENT DECAY
15 10 5 0
0 5 10 15 20 25 30 35 40 45 50
FOUR DAYS IN CAR
1.0 ON WITHDRAWAL 0.0
0.0 ONE DAY LATER 1.1
SIX DAYS IN CAR
0.0 ON WITHDRAWAL 0.2
5.7 ONE DAY LATER 12.6
EIGHT DAYS IN CAR
0.0 ON WITHDRAWAL 4.8
3.9 ONE DAY LATER 18.6

FIG. 22.—Diagram illustrating the percentage of decay in precooled and nonprecooled carefully handled red raspberries shipped from Puyallup, Wash., to Grand Forks, N. Dak., season of 1912.

raspberries in maximum good condition while in transit. Table 6 and Figure 22 show the results of the carefully handled precooled and nonprecooled shipments.

TABLE 6.—*Decay in carefully handled red raspberries shipped to Grand Forks, N. Dak., under ordinary icing, with and without precooling, in 1912.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Precooled.	Nonprecooled.	Precooled.	Nonprecooled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	1.0	0	0	1.1
6 days	0	.2	5.7	12.6
8 days	0	4.8	3.9	18.6

The precooled carefully handled berries showed practically no decay on withdrawal after four, six, and eight days in the car, except 1 per cent after four days. This is an apparent discrepancy, but it is easily accounted for when one considers that it is impossible to use the same lots for inspection more than once. The non-

precooled berries showed no decay at the first withdrawal, 0.2 per cent of decay at the second, and 4.8 per cent of decay at the end of the 8-day period. The after-withdrawal inspections, after the fruit had been held on the market for one day, are even more striking and instructive. The first market-holding inspection of the precooled fruit showed it to be apparently sound, while at the second inspection there had developed 12.6 per cent of decay and at the third inspection there was found 18.6 per cent of decay. While there was little difference between the precooled and nonprecooled fruit at the withdrawal inspections, there was quite a marked difference in favor of the precooled berries in the market-holding inspections. The non-

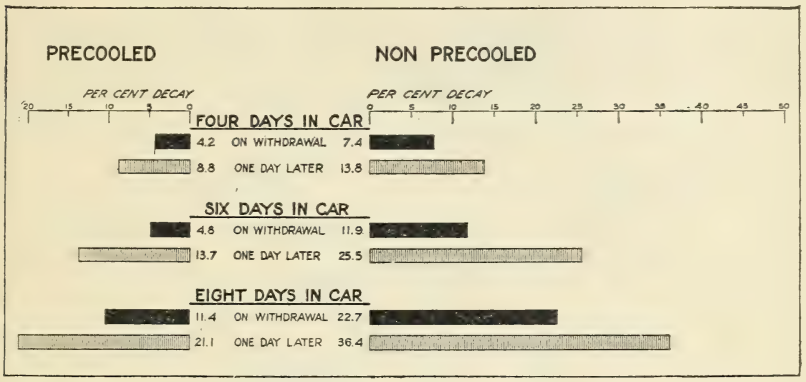

FIG. 23.—Diagram illustrating the percentage of decay in precooled and nonprecooled commercially handled red raspberries shipped from Puyallup, Wash., to Grand Forks, N. Dak., season of 1912.

precooled fruit apparently was somewhat riper, having ripened or matured more rapidly under the higher temperatures in the cars not precooled, and it therefore commenced to break down sooner than the precooled fruit.

The effect of precooling on commercially handled fruit is equally consistent with the results of the season of 1911, as shown in Table 7 and Figure 23. It is unnecessary to discuss these data in detail.

TABLE 7.—*Decay in commercially handled red raspberries shipped to Grand Forks, N. Dak., under ordinary icing, with and without precooling, in 1912.*

Time in iced car.	Decay on withdrawal.		Decay 1 day after withdrawal.	
	Precooled.	Nonprecooled.	Precooled.	Nonprecooled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	4.2	7.4	8.3	13.8
6 days	4.8	11.9	13.7	25.5
8 days	11.4	22.7	21.1	36.4

While again emphasizing the beneficial effects of precooling, these results emphasize even more strongly the importance of careful handling. The difference in decay between the precooled and nonprecooled berries indicates clearly the effect of temperature on the acceleration or retardation of the ripening processes and the growth of mold fungi. The more promptly the fruit is cooled and the lower the temperature (without actual freezing) at which the fruit

is held in transit, the more quickly and completely are the ripening processes checked and the slower is the growth of mold fungi.

TABLE 8.—*Decay in carefully handled precooled and commercially handled non-precooled red raspberries shipped to Grand Forks, N. Dak., in 1912.*

Time in iced car.	Decay on withdrawal.		Decay 2 days after withdrawal.	
	Carefully handled precooled.	Commercially handled non-precooled.	Carefully handled precooled.	Commercially handled non-precooled.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4 days	1.0	7.4	0	13.8
6 days	0	11.9	5.7	25.5
8 days	0	22.7	3.9	36.4

Table 8 and Figure 24 give a comparison of decay in cars of precooled, carefully handled fruit and nonprecooled, commercially handled fruit, which can not fail to be impressive. Careful handling

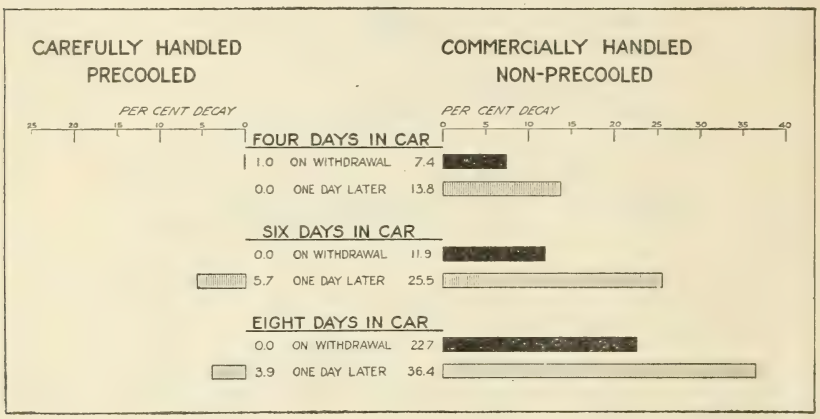
CAREFULLY HANDLED PRECOOLED
COMMERCIALLY HANDLED NON-PRECOOLED
PER CENT DECAY
PER CENT DECAY
25 20 15 10 5 0
0 5 10 15 20 25 30 35 40
FOUR DAYS IN CAR
1.0 ON WITHDRAWAL 7.4
0.0 ONE DAY LATER 13.8
SIX DAYS IN CAR
0.0 ON WITHDRAWAL 11.9
5.7 ONE DAY LATER 25.5
EIGHT DAYS IN CAR
0.0 ON WITHDRAWAL 22.7
3.9 ONE DAY LATER 36.4

FIG. 24.—Diagram illustrating the percentage of decay in carefully handled precooled red raspberries in comparison with commercially handled nonprecooled red raspberries shipped from Puyallup, Wash., to Grand Forks, N. Dak., season of 1912.

with precooling made possible an 8-day trip with sound delivery and practically no spoilage during the market-holding period, while the commercially handled fruit nonprecooled showed 7.4 and 22.7 per cent of decay, respectively, at the end of 4 and 8 day transit periods, with 13.8 per cent of decay and 36.4 per cent of decay at the respective market-holding inspections.

DECAY IN TOP AND BOTTOM CRATES.

The temperature effect is again strikingly emphasized in a comparison of decay in the top and bottom crates in a refrigerator car. It has been conclusively demonstrated that there is a marked difference in temperature at the bottom and the top of the load in an iced car. This difference is usually more than 10 degrees and less than 20 degrees. In the nonprecooled lots the bottom crates showed 5.5 per cent of decay and the top crates of the same fruit 9.4 per cent of decay at the end of four days. A study of Table 9 and Figure 25 shows these differences to be consistent for all inspections. The precooled cars show similar differences, the bottom having 2.6 per cent of decay and the top 5.6 per cent at the first withdrawal inspection.

TABLE 9.—*Decay in the top and bottom tiers in commercially handled red raspberries shipped to Grand Forks, N. Dak., under ordinary icing, with and without precooling, in 1912.*

Time in iced car.	Decay, precooled.				Decay, nonprecooled.			
	On withdrawal.		1 day after withdrawal.		On withdrawal.		1 day after withdrawal.	
	Top.	Bottom.	Top.	Bottom.	Top.	Bottom.	Top.	Bottom.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4 days	5.6	2.6	10.4	7.3	9.4	5.5	18.9	8.7
6 days	6.5	3.0	16.1	11.1	14.2	9.6	30.5	20.5
8 days	15.6	7.3	24.9	17.1	28.1	17.4	44.0	28.7

TEMPERATURE CONDITIONS IN AN ICED REFRIGERATOR CAR.

Temperature readings taken during the season of 1913 in a car of blackberries in transit from Puyallup to Grand Forks show clearly the reason for the marked differences in decay in berries in the top

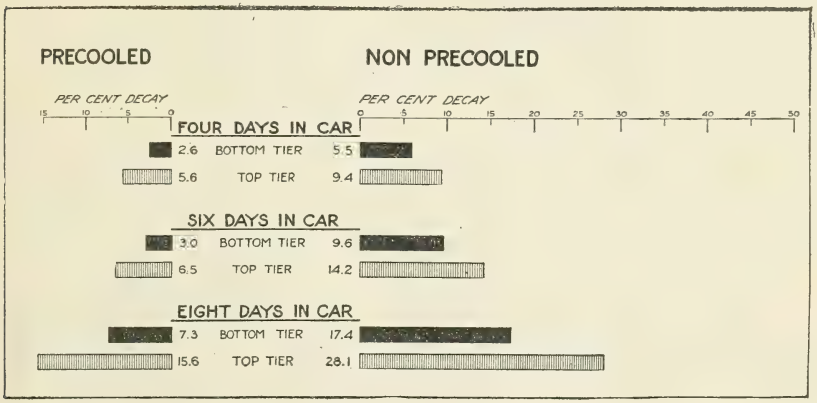
PRECOOLED
NON PRECOOLED
PER CENT DECAY
PER CENT DECAY
15 10 5 0
0 5 10 15 20 25 30 35 40 45 50
FOUR DAYS IN CAR
2.6 BOTTOM TIER 5.5
5.6 TOP TIER 9.4
SIX DAYS IN CAR
3.0 BOTTOM TIER 9.6
6.5 TOP TIER 14.2
EIGHT DAYS IN CAR
7.3 BOTTOM TIER 17.4
15.6 TOP TIER 28.1

FIG. 25.—Diagram illustrating the percentage of decay on withdrawal in bottom and top tiers in precooled and nonprecooled commercially handled red raspberries shipped from Puyallup, Wash., to Grand Forks, N. Dak., season of 1912.

and bottom tiers. Figure 26 illustrates this range of temperatures. The upper curve shows the temperature of the fruit in the top tier, temperature readings being taken at the following points: Next to the bunker, halfway from the bunker to the door, and in the middle of the car. The temperatures in the lower curve were taken in the bottom tier in the same relative positions in the car and were the average of readings taken at three points, the same as in the upper curve. The middle curve is simply an average of the top and bottom tier readings. In some cases the difference in average temperature between the top and bottom crates was more than 20 degrees, enough to account for the difference in decay in the fruit in the top and bottom tiers. The lesser difference at the beginning of the trip is partly accounted for by the fact that the car was partially precooled before shipment. The data presented in these curves emphasizes strongly the necessity of loading the car in such a way as to afford the freest possible circulation of cold air from the bunkers to all portions of the car.

It is not uncommon where salt has been added at each re-icing en route to find spoilage both from freezing and from deterioration on account of too high temperatures. In such cases the temperature at the floor next to the iced bunkers becomes sufficiently low to cause the freezing of some of the fruit on the floor in the ends of the car, while at the top in the middle of the car the temperature is often so high that the fruit is in an overripe condition. The temperature tests made in fully loaded cars of berries in transit would indicate that it is not ordinarily advisable to add salt in re-icing after the first 40 hours in transit. During the first part of the journey and before shipment no doubt the addition of a certain percentage of salt to the crushed ice in the bunker greatly aids in obtaining quick cooling, but the addition of salt at each re-icing during a journey of over 40 hours may result in considerable damage by freezing in certain portions of the car. If there was some way of circulating the cold air throughout the car so as to prevent the formation of cold pockets. salting throughout at every re-icing would doubtless be highly beneficial. Possibly the use of slats or racks on the floor would facilitate the free circulation of cold air sufficiently to avoid the danger of freezing, even though salting was practiced throughout en route.

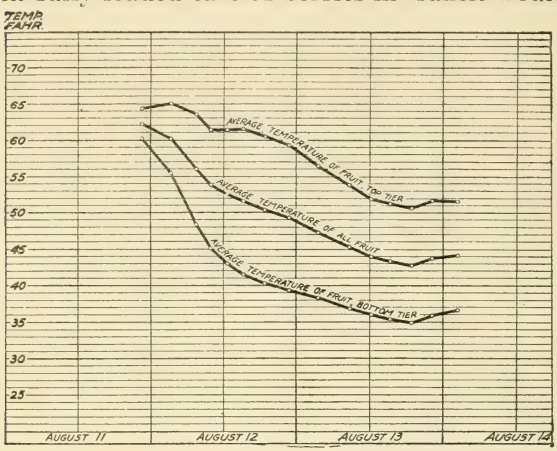

FIG. 26.—Diagram illustrating the average temperature of fruit in top and bottom tiers and average temperature of all fruit in the car of blackberries in transit from Puyallup, Wash., to Grand Forks, N. Dak., season of 1913.

THE APPLICATION OF PRECOOLING.

As a result of these investigations, every effort has been made by the industry to procure proper handling, and a precooling plant has been erected for cooling the fruit after loading it into the cars. After observing the methods of operating a number of precooling plants, one is impressed with the need of organizing or adjusting the fruit picking and delivery so as to allow sufficient time to precool the fruit successfully before it enters upon its journey to a distant market. The most serious and common fault is that of allowing too little time for precooling; that is, attempting to do precooling in less than half or quarter of the time actually necessary to accomplish the desired results. Our experience has demonstrated beyond question that the effective precooling of berries can not successfully be accomplished in less than four or five hours. The precooling of a car, fully loaded, for an hour or two hours accomplishes little in the way of actual temperature reduction or in results from the standpoint of the condition of the fruit on arrival. The investigations of

the Department of Agriculture, as above reported, have demonstrated clearly the beneficial results of precooling red raspberries, but to get full value out of the money expended in precooling it is absolutely necessary to do it properly and well.

Precooling can not be depended on to offset the bad effects of careless, rough handling, and for such purpose is not justified any more than is a half job of precooling of either properly or improperly handled berries. Thorough precooling of properly handled red raspberries is fully justified by the results and is of the greatest assistance in delivering berries to the market in good condition. Any association, organization, or individual wishing to utilize precooling in connection with the long-distance shipment of berries should adapt the picking and handling operations to the needs of the situation, so as to permit sufficient time for thorough precooling. Otherwise, the money put into precooling is very largely wasted.

SUMMARY.

The results of these investigations demonstrate that the care exercised in handling and the promptness with which the fruit is cooled are among the most important factors determining the distance over which red raspberries can be successfully shipped. These two factors, more than any other, determine the condition of the berries on arrival at the market and the area of successful distribution. In connection with the handling and shipping of fresh red raspberries the following recommendations are made.

While methods of growing, pruning, and training have primarily in view the production of the largest possible crop at the most profitable period during the season, the grower should also keep in mind the ease or difficulty of harvesting. If the methods of growing, pruning, and training are such as to facilitate picking, there will be less liability to injury to the fruit in handling. Too close planting or the nonseparation of bearing from nonbearing canes increases the difficulty of doing the picking either thoroughly or properly.

Before the harvesting season commences all surplus new growth should be cut out and the remaining new canes separated from the bearing vines in such a way as to facilitate finding and picking the fruit with the least amount of injury.

In picking, three fingers should be used to remove the berry from the receptacle instead of two, as is the common practice. Three fingers distribute the pressure and lessen the liability to injury.

Each berry should be placed in a cup as soon as removed from the vine, in order to avoid mashing. When several berries are held in the hand while picking it is difficult to avoid crushing them. Crushing or bruising from any cause is to be avoided, as it is often the cause of serious losses on the market.

The greatest care should be exercised in sorting to place only firm, good-shipping berries in shipping cups and all soft, overripe, injured berries in canning cups. The inclusion of one overripe berry in a cup may spoil the whole cup, one cup a whole crate, and a few such crates a whole carload.

It is very important that the yards be picked over so frequently that an undue proportion of berries will not become overripe. The frequent picking over of a patch makes good sorting in picking

much easier of accomplishment. The 6-basket carrier used in picking should be kept in the shade, and as soon as the cups are filled or the picking completed the berries should be taken to the sorting shed.

No sorting over of berries in any individual cup should be attempted or permitted, owing to injuries resulting from rehandling. Sorting or grading at the shed must necessarily be confined to grading by cups, cups showing overripe or mashed berries to be placed in canning crates or in crates for local shipment only. Cups containing only sound, firm berries should be placed in shipping crates.

The berries should be hauled to the receiving station on wagons provided with good springs and they should be covered to protect them from both dust and the sun.

In handling to and from the wagon and to the car the utmost care consistent with commercial requirements and conditions should be exercised to keep the crates in a horizontal position. Tipping crates on end may result in much decay, as the berries are bruised in rolling around in the cups and oftentimes mashed against the cover.

The berries should be brought in as promptly as possible after picking and promptly placed in a refrigerator car or cooling room, if one is available. Delay, especially in warm weather, in handling the berries, either in the field or at the receiving station, may shorten the life of the fruit and is commonly the cause of serious losses.

Every precaution should be taken to have the cars iced 12 to 24 hours prior to loading and to keep the car doors open only when actually loading.

The cars should be so loaded as to allow free circulation of air between tiers of crates, in order to facilitate quick, effective cooling.

The crates themselves should be, as far as is consistent with the strength of the packages, the cost of manufacture, etc., partially slatted on the bottom and sides to permit free circulation of the air and quicker refrigeration.

Strips or racks on the floor would aid very materially in bringing about the quicker and more uniform cooling of the load. The circulation would be much freer and more rapid, lessening the temperature inequalities shown between the top and bottom tiers and various parts of the load.

The rather common practice of putting in from 100 to 200 pounds of salt at the first re-icing after loading and at each re-icing in transit is on the whole beneficial. If the salting of the ice, however, is continued beyond 40 hours, or thereabouts, it may result in serious damage by freezing the fruit in the bottom crates next to the bunkers.

Where the fruit has been precooled the addition of salt during the first two or three re-icings will no doubt be beneficial, but salt should be used more sparingly than where used with nonprecooled cars. If the raspberries are to be precooled, there should be the least possible delay between picking and precooling.

The precooling should be thorough, whether done before or after loading. Half or partial precooling is not justified. In order to do the precooling promptly and to allow sufficient time in which to do it thoroughly, the operations of picking, of hauling to the receiving station, of loading, of moving cars, and of precooling must be made to conform, as far as possible, to train schedules. Precooling can not be depended upon to counteract the bad effects of rough and careless handling methods.

○